Chemistry 3.6 **Worksheet** Name _____

Question One

The K_a for propanoic acid is 1.35×10^{-5} mol L^{-1} at 25^0C

(a) Write the K_a expression for the dissociation of propanoic acid, CH_3CH_2COOH.

$$CH_3CH_2COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3CH_2COO^-_{(aq)} + H_3O^+_{(aq)}$$

$$K_a = \frac{[CH_3CH_2COO^-][H_3O^+]}{[CH_3CH_2COOH]}$$

(b) Calculate the pH of a 0.120 mol L^{-1} solution of propanoic acid at 25°C. Include any assumptions you may make.

Assumptions are…

Most of the $CH_3CH_2COOH_{(aq)}$ does not dissociate as the K_a is small. $[CH_3CH_2COOH] = 0.120$ molL^{-1}

Also $[CH_3CH_2COO^-] = [H_3O^+]$ because H_3O^+ from water dissociation is significantly small

$$K_a = \frac{[H_3O^+]^2}{cCH_3CH_2COOH} = \frac{[H_3O^+]^2}{0.120} = 1.35 \times 10^{-5}$$

$$[H_3O^+] = \sqrt{(1.35 \times 10^{-5} \times 0.120)} = 0.001273 molL^{-1}$$

pH = -log(0.001273) = <u>2.90</u>

(c) Calculate the pH of a 0.120 molL^{-1} solution of sodium propanoate at 25°C. Include any assumption you may make.

$$CH_3CH_2COO^-_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3CH_2COOH_{(aq)} + OH^-_{(aq)}$$

$$K_b = \frac{[CH_3CH_2COOH][OH^-]}{[CH_3CH_2COO^-]}$$

$$K_b = \frac{K_w}{K_a} = \frac{10^{-14}}{1.35 \times 10^{-5}} = 7.41 \times 10^{-10}$$

Assumptions are…

Most of the $CH_3CH_2COO^-$ does not dissociate as K_b is small. $[CH_3CH_2COO^-] = 0.120$ molL^{-1}

Also $[CH_3COOH] = [OH^-]$ because $[OH^-]$ from water dissociation is significantly small

$$K_b = \frac{[OH^-]^2}{cCH_3CH_2COO^-} = \frac{[OH^-]^2}{0.120} = 7.41 \times 10^{-10}$$

$$[OH^-] = \sqrt{(7.41 \times 10^{-10} \times 0.120)} = 9.43 \times 10^{-6} molL^{-1}$$

$$[H_3O^+] = \frac{K_w}{[OH^-]} = \frac{10^{-14}}{9.43 \times 10^{-6}} = 1.06 \times 10^{-9} molL^{-1}$$

pH = -log(1.06×10^{-9}) = <u>8.97</u>

(d) What is the concentration of propanoic acid in the solution that gives a pH of 4.5

$$K_a = \frac{[H_3O^+]^2}{cCH_3CH_2COOH}$$

$[H_3O^+] = 10^{-pH} = 10^{-4.5} = 3.16 \times 10^{-5}$ molL^{-1}

$$1.35 \times 10^{-5} = \frac{[3.16 \times 10^{-5}]^2}{cCH_3CH_2COOH}$$

$$cCH_3CH_2COOH = \frac{[3.16 \times 10^{-5}]^2}{1.35 \times 10^{-5}} = 7.41 \times 10^{-5} molL^{-1}$$

Question Two

Shellfish build shells mainly of calcium carbonate, which is only slightly soluble in water.

$$CaCO_{3\,(s)} \rightleftharpoons Ca^{2+}{}_{(aq)} + CO_3{}^{2-}{}_{(aq)}$$

(a) Write the K_s expression for $CaCO_3$

$$K_s = [Ca^{2+}][CO_3{}^{2-}]$$

(b) K_s for $CaCO_3$ at 25°C is 5.0×10^{-9}. Calculate the solubility of $CaCO_3$ in pure water.

$CaCO_3$ is an AB type salt

$$Solubility = \sqrt{K_s} = \sqrt{5.0 \times 10^{-9}} = 7.07 \times 10^{-5} molL^{-1}$$

(c) What would be the solubility of $CaCO_3$ in 0.1 $molL^{-1}$ of Na_2CO_3

$$K_s = [Ca^{2+}][CO_3{}^{2-}]$$

$$5.0 \times 10^{-9} = [Ca^{2+}] \times 0.1$$

$$[Ca^{2+}] = solubility = \frac{5.0 \times 10^{-9}}{0.1} = 5 \times 10^{-8} molL^{-1}$$

(d) Discuss with equations and calculations if a precipitate of $CaCO_3$ will form when 85 mL of sea water with Ca^{2+} concentration of 0.0260 $molL^{-1}$ is mized with 900 mL of Na_2CO_3 solution with a concentration of 0.020 $molL^{-1}$

Amount of Ca^{2+} = 0.026 $molL^{-1}$ × 0.085 L = 0.00221 mol

Amount of $CO_3{}^{2-}$ = 0.02 $molL^{-1}$ × 0.9 L = 0.018 mol

$[Ca^{2+}]$ = 0.00221 mol ÷ (0.085 + 0.9) L = 0.002244 $molL^{-1}$

$[CO_3{}^{2-}]$ = 0.018 mol ÷ (0.085 + 0.9) L = 0.018274 $molL^{-1}$

IP = $[Ca^{2+}][CO_3{}^{2-}]$ = 0.002244 $molL^{-1}$ × 0.018274 $molL^{-1}$ = 4.1×10^{-5}

IP > K_s therefore the mixture is over saturated, precipitate will form.